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# *Geastrum* species from the Amazon Forest, Brazil

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Abstract—Six *Geastrum* species are reported from the Amazon forest: *G. entomophilum*, *G. fimbriatum*, *G. javanicum*, *G. lageniforme*, *G. lilloi,* and *G. saccatum*. *Geastrum javanicum* and *G. lilloi* represent first records from Brazil. Descriptions and illustrations of the species and SEM images of microstructures are given.

Key words— *Basidiomycota*, *Geastraceae*, gasteromycetes, taxonomy

## Introduction

The family *Geastraceae* was first described by Corda (1842) as the *Geastrideae* and subsequently classified in the *Lycoperdales* (Lloyd 1902, Ponce de León 1968, Krüger & Chagas 2008), the *Phallales* (Hibbett et al. 1997) and, based on molecular data, recently in the *Geastrales* (Hosaka et al. 2006). With 43 species reported, the *Geastraceae* is the second-most represented gasteromycete family in Brazil (Trierveiler-Pereira & Baseia 2009). The *Geastraceae* comprise eight genera: *Geastrum*, *Myriostoma*, *Trichaster*, *Geasteropsis*, *Phialastrum*, *Pyrenogaster*, *Radiigera,* and *Terrostella*, with *Geastrum* being the largest (Sunhede 1989) with 50 species recognized worldwide (Kirk et al. 2008).

Tropical regions contain most of the fungi still unknown to science. Tropical Amazonian rainforests account for 25% of the remaining forests worldwide and cover nearly half of Brazil, representing enormous strategic value (Braga-Neto et al. 2008). The Amazon biome, which covers 4,871,000 km² (INPE

2004), extends from the Atlantic Ocean to the eastern slopes of the Andes up to approximately 600 m altitude, encompassing parts of nine South American countries and with 69% falling within the boundaries of Brazil (Ab'Sáber 1977).

The mycobiota of the Brazilian Amazon has been poorly studied and needs to be more thoroughly investigated. However, the following existing studies are noteworthy: Singer & Araujo (1979), Aguiar (1984), Singer (1984), Singer & Aguiar (1986), Capelari & Maziero (1988), and Bononi (1992). Several studies on gasteromycetes in the Amazon region have been conducted: Berkeley & Cooke (1876), Hennings (1904), Capelari & Maziero (1988), Trierveiler-Pereira et al. (2009). The purpose of this paper is to contribute to the existing knowledge of this mycobiota, with special reference to the family *Geastraceae*.

## Material & methods

Material was collected from 1995 to 2008 at the Reserva Nacional de Caxiuanã, in the municipality of Melgaço, Pará state, Amazonas, Brazil, and deposited in the herbaria of the Museu Paraense Emílio Goeldi (MG), Belém, Pará, and UFRN, Universidade Federal do Rio Grande do Norte, Natal. These collections are considered reference depositories for the study of Amazonian biodiversity (Braga-Neto et al. 2008). Additional Brazilian specimens held in UFRN were also studied. Macro- and microscopic characters were studied according to Miller & Miller (1988), Sunhede (1989), Ponce de León (1968), Soto & Wright (2000), Baseia & Milanez (2002), Calonge et al. (2000), Calonge & Mata (2004), Baseia & Calonge (2006), Leite & Baseia (2007), and Leite et al. (2007). Color citations were based on Kornerup & Wanscher (1978). Microstructures were analyzed in sections mounted on slides, using 5% KOH, and SEM was used to study basidiospore ornamentation.

## Results

***Geastrum entomophilum*** Fazolino, Calonge & Baseia, Mycotaxon 104: 450 (2008).

Fig. 1

Expanded basidiome epigeous, 7.3 cm broad. Exoperidium semi-hygroscopic, arched, split into 6 rays, recurved under the exoperidial disc; mycelial layer light orange (6A5), covered with adhering humus, leaf and sand; fibrous layer light orange (6A4); pseudoparenchymatous layer brown (6F4). Endoperidium sessile, globose to subglobose, 2 cm diam., ornamentation formed by fascicles of worm-shaped surface hyphae (Fig. 1b), greyish brown (5D3). Peristome fibrillose, concolorous with rest of endoperidium, indistinctly delimited. Gleba brownish grey (5F2). Basidiospores globose, ornamentation more or less columnar, 3.5–4 µm diam. Capillitial hyphae with verrucose surface, 3–3.1 µm diam.

Substrate & distribution— Sandy soil. Known only from South America, this is the first record of this species from the Amazon rainforest.

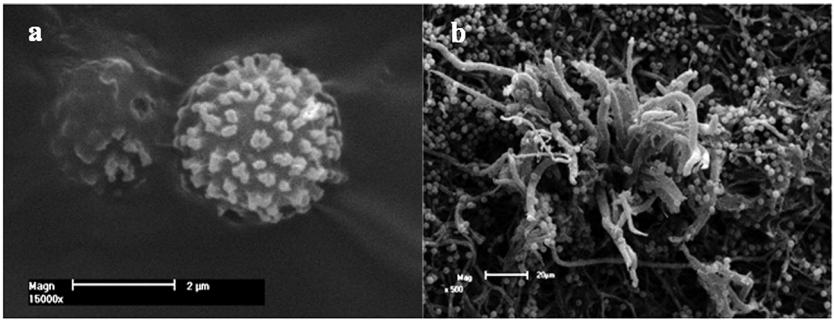


Fig. 1. *Geastrum entomophilum*. a. Basidiospores; b. Endoperidial hyphal fascicle.

Specimen examined: **BRAZIL. Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 20.II.1997, col. H. Sotão & al. (MG 199685).

Additional specimen examined: **BRAZIL. Rio Grande do Norte**: Natal, Parque Estadual Dunas do Natal, 15.VII.2006, col. E.P. Fazolino & A.G. Leite. (UFRN-Fungos 354).

Taxonomic remarks—*Geastrum entomophilum* is recognized by its sessile endoperidium, verrucose surface with vermiform hyphae in fascicles, and fibrillose and lacerated peristome, non-delimited when older. In the original description (Fazolino et al. 2008) the small beetles (*Coleoptera*) observed inside the gleba led to the name '*entomophilum*.' Beetles were not observed by Trierveiler-Pereira & Baseia (2010).

***Geastrum fimbriatum*** Fr., Syst. mycol. 3(1): 16 (1829). Fig. 2

Basidiomata epigeous when young, globose to depressed-globose, 1.7 cm diam. × 2 cm high, epigeous at maturity, 2–2.5 cm broad, 0.4–0.7 cm high. Exoperidium non-hygroscopic, saccate, splitting into 4–6 rays; mycelial layer dark blond (5D4); fibrous layer adherent, greyish yellow (4B3); pseudoparenchymatous layer brown (5F5). Endoperidium sessile, globose to subglobose, 0.8–2 cm diam., brown (6E4). Peristome absent to fibrillose. Gleba dark brown (6F5); columella present. Basidiospores 3–3.5 µm diam., globose, ornamentation columnar. Capillitial hyphae thick-walled, with surface debris and verrucose, 3.5–5 µm diam.

Substrate & distribution— Sandy soil. Known from South America, Central America, North America, Europe, and Australasia.

Specimen examined: **BRAZIL. Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 30.V.1997, col. H. Sotão & al. (MG-199687, UFRN-fungos 1465).

Additional specimen examined: **BRAZIL. Rio Grande do Norte**: Parque Estadual Dunas do Natal, 02.VI.2007, col. E.P. Fazolino & B.D.B. Silva (UFRN-Fungos 337).

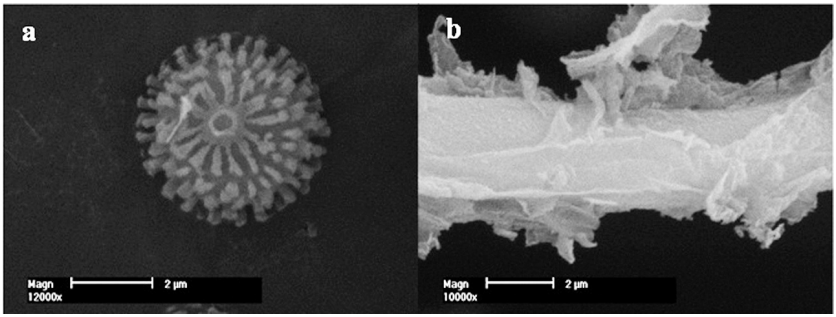


Fig. 2. *Geastrum fimbriatum*. a. Basidiospore; b. Capillitial hypha.

Taxonomic remarks—*Geastrum fimbriatum* strongly resembles *G. saccatum*, mainly with respect to its basidiospore ornamentation, but it also differs in having smaller spores, with those of *G. saccatum* 4–6 µm diam. (Soto & Wright 2000). A marked characteristic in this species observed by both Sunhede (1989) and us is the interspersed hyphal formation in the mycelial layer.

This is the second record of *C. fimbriatum* from the Amazon rainforest; the first was made by Trierveiler-Pereira et al. (2009).

***Geastrum javanicum*** Lév., Annls Sci. Nat., Bot., sér. 3, 5: 161 (1846). Fig. 3-4

Basidiomata epigeous when young, 0.7–1.6 cm broad, 0.5–1.5 cm high, caespitose on a subiculum, white yellowish (4A1–4A2); expanded basidiome epigeous. Exoperidium hygroscopic, 1.5–1.9 cm diam. when open, split into 5–8 recurving rays; mycelial layer velvety, separates at maturity, greyish brown (5D3); fibrous layer light yellowish (5C4); pseudoparenchymatous layer brownish orange (5C4). Endoperidium brown (6F4) to brownish grey (7E2), sessile, globose, 1–1.2 cm diam. Peristome delimited, fibrillose, concolorous with rest of endoperidium. Gleba greyish brown (6F3); columella present.

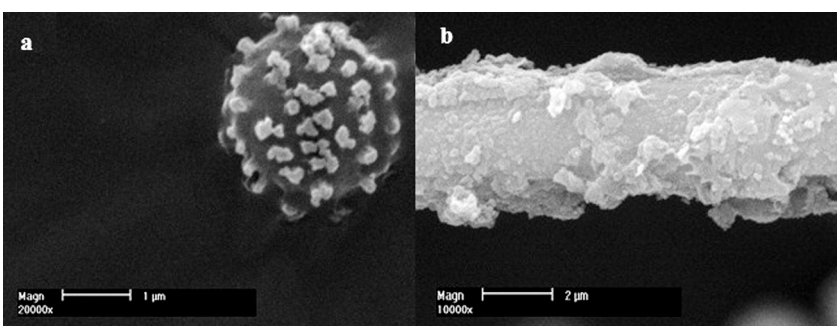


Fig. 3. *Geastrum javanicum*. a. Basidiospore; b. Capillitial hypha.

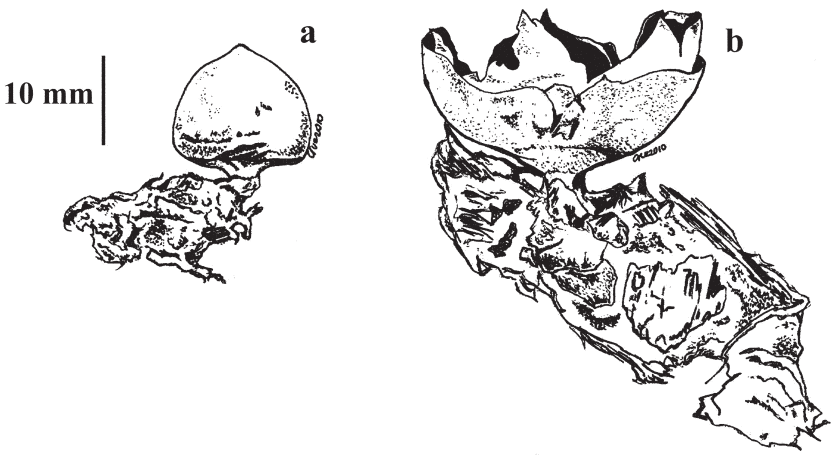


Fig. 4. *Geastrum javanicum.* a. Immature basidioma; b. Mature basidioma.

Basidiospores globose, 2.5–3 µm diam., with irregular warts. Capillitial hyphae, 3–4 µm diam., surface rugose, septate and branched.

Substrate & distribution—Decaying wood. Known from South America, Central America, North America, Africa, Australasia, Asia.

Specimen examined: **BRAZIL. Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 12.IV.1995, col. H. Sotão & al. (MG nº 0149528).

Additional specimen examined: **BRAZIL. Rio Grande do Norte**: Parnamirim, Mata do Jiqui, 22.VI.2007, col. E.P. Fazolino & al. (UFRN-Fungos 550).

Taxonomic remarks—*Geastrum javanicum* is generally found growing in clusters, forming whitish subiculum on dead wood, leaf litter, and occasionally in sand impregnated with decomposing organic matter (Ponce de León 1968). A diagnostic character is the velvety exoperidium that detaches itself from the mycelial layer when the basidioma is mature. Ponce de León (1968) reviewed the holotypes of *G. velutinum* Morgan and *G. javanicum* and considered them to be synonyms. However, on the basis of priority, *G. javanicum* is the correct name to use. Sunhede (1989) did not study the type of material of *G. javanicum*, and therefore did not confirm its synonymy with *G. velutinum*.

This species has been reported from Brazil by Sobestiansky (2005), de Meijer (2006), and Sydow & Sydow (1907) as *G. velutinum*, but this is the first record from the Amazon rainforest.

***Geastrum lageniforme*** Vittad., Monograph. Lyc.: 16 (1842). Fig. 5

Mature basidiomata 1–2.4 cm broad, 0.8–1.4 cm high. Exoperidium non-hygroscopic, saccate with 4–6, long, slender-tipped rays, extended or recurved

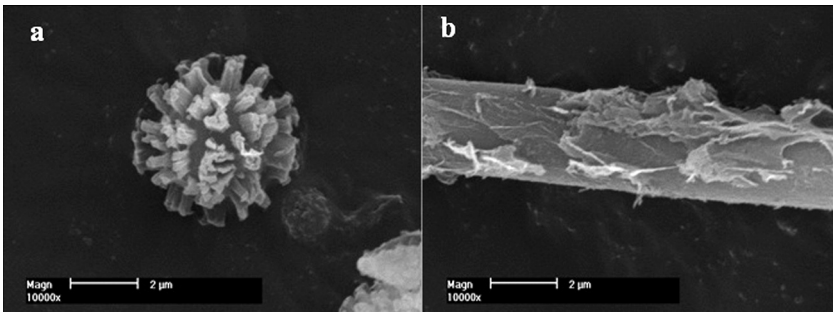


Fig. 5. *Geastrum lageniforme*. a. Basidiospore; b. Capillitial hypha.

under the exoperidial disc and the rays are markedly tapered and pointed; mycelial layer blond (4C4), with longitudinal fissures; fibrous layer pale orange (5A3); pseudoparenchymatous layer yellowish brown (5F8). Endoperidium dark blond (5D4), sessile, globose to subglobose, 0.8–1.2 cm diam. Peristome fibrillose, delimited, conical to mammiform. Gleba pale orange (5A3); columella present. Basidiospores globose 4.5–5 µm diam., ornamentation columnar. Capillitial hyphae thick-walled, 2–2.8 µm diam.

Substrate & Distribution—Sandy soil. Known from South America, Central America, North America, and Europe; this is the first record of this species from the Amazon rainforest.

Specimen examined: **BRAZIL. Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 19.II.1997, col. H. Sotão & al. (MG 199683).

Additional specimen examined: **BRAZIL. Rio Grande do Norte**: Natal, Parque Estadual Dunas do Natal, 29.VII.2006, col. E.P. Fazolino & al. (UFRN-fungos 332).

Taxonomic remarks—This species is characterized by a saccate exoperidium, sessile endoperidium and fibrillose, well-delimited peristome. It is very similar to and often confused with *G. saccatum* and *G. triplex* Jungh. (Soto & Wright 2000). Fries (1829) mentions nothing about grooves in the mycelial layer in *G. saccatum*. In *G. lageniforme*, after dehiscence of the exoperidium, the rays are markedly longitudinally cracked. According to Sunhede (1989), *G. triplex* exhibits an endoperidial body of 7.5–19.5 mm diam., while in *G. lageniforme* it reaches 11–54 mm.

***Geastrum lilloi*** L.S. Domínguez, Mycologia 88: 858 (1996). Figs. 6-7

Young basidiomata epigeous, 0.8 cm broad, 0.4 cm high, surface irregular, yellowish white pale (2A2), caespitose, growing on a pale yellow (4A3) subiculum; mature basidiomata 1.1–1.4 cm diam. Open exoperidium saccate, splitting into 5–6 rays, hygroscopic; mycelial layer with irregular surface, pale yellowish white (2A2); fibrous layer white (6D4); pseudoparenchymatous layer

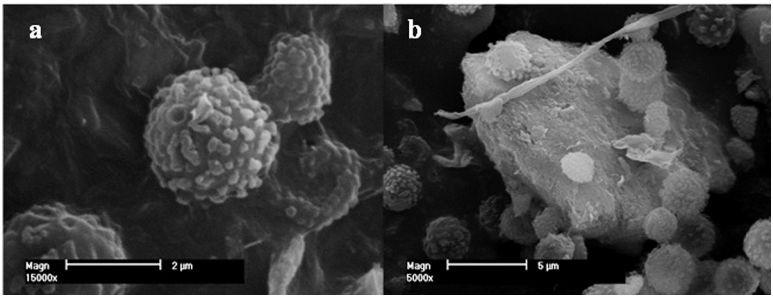


Fig. 6. *Geastrum lilloi.* a. Basidiospores; b. Mycosclereid.

brown (5F7). Endoperidium brown (6E4), sessile, globose, 0.6–0.8 cm diam. Peristome fibrillose, mammiform, greyish brown (5D3), indistinctly delimited. Gleba dark brown (6F3); mycosclereids present, up to 10.2 × 15.9 µm diam.; columella present. Basidiospores globose, 2.8–3.5 µm diam., ornamentation irregularly columnar. Capillitial hyphae 1.8–2 µm. diam., covered with encrusting surface debris.

Substrate & distribution—Woody debris. Known from South America (Argentina, Brazil).

Specimen examined: **BRAZIL**. **Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 29.V.1997, col. H. Sotão & al. (MG 199686).

Taxonomic remarks—Distinguishing characteristics of *G. lilloi* are its small size, gregarious and xylophilous habitat, velvety mycelial layer, the presence of mycosclereids in the gleba, the endoperidium with a fibrillose, mammiform pore, and epigeal development (Domínguez de Toledo 1996). *Geastrum schweinitzii* (Berk. & M. A. Curtis) Zeller can easily be confused with *G. lilloi* because it also is small-sized and grows on a subiculum on wood. However,

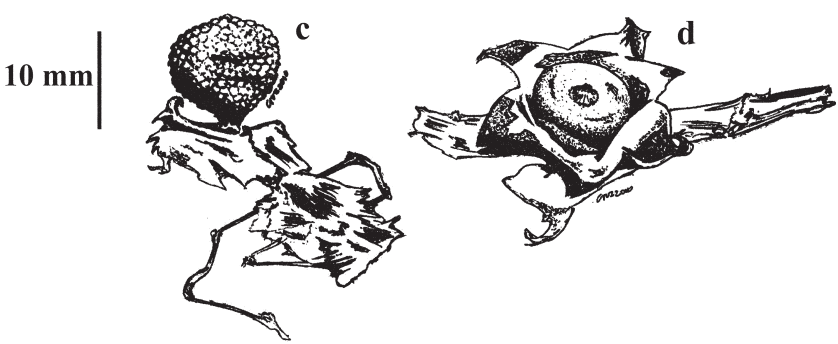


Fig. 7. *Geastrum lilloi.* a. Immature basidioma; b. Mature basidioma.

these two species differ in terms of the non-hygroscopic exoperidium, obovate fruit body, peristome without a ring, and smooth to velvety mycelial layer in *G. schweinitzii*.

This is the first record of *G. lilloi*, first described from Argentina, from Brazil.

***Geastrum saccatum*** Fr., Syst. Mycol. 3(1): 16 (1829). Fig. 8

Mature basidiomata 0.5–2 cm diam. Exoperidium non-hygroscopic, saccate, splitting into 5–7 rays; mycelial layer encrusted with debris of soil and leaf litter, light orange (6A4); pseudoparenchymatous layer brown (6E4); fibrous layer adhered to pseudoparenchymatous layer, pale orange (6A3). Endoperidium brownish beige (6E3), sessile, globose, 0.8–1.2 cm diam. Peristome well delimited, fibrillose, conical to mammiform, concolorous with rest of endoperidium. Gleba greyish brown (6F3); columella present. Basidiospores globose to subglobose, 3.6–4.5 µm diam., ornamentation rather irregular columnar. Capillitial hyphae 3–3.5 µm diam, covered with small wart-like surface outgrowths.

Substrate & distribution— Sandy soil. Known from South America, Central America, North America, Africa, Asia, Australasia, and Europe.

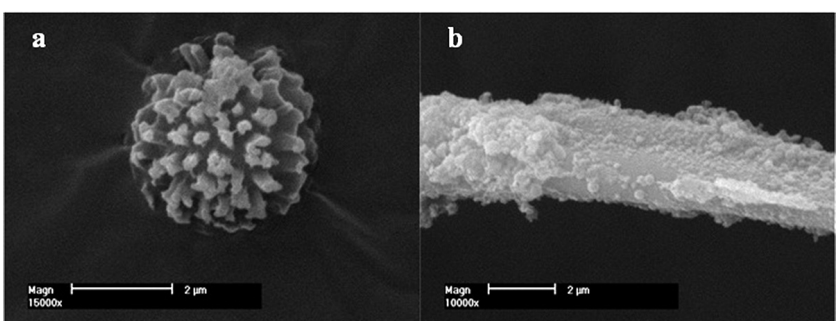


Fig. 8. *Geastrum saccatum.* a. Basidiospore; b. Capillitial hypha.

Specimen examined: **BRAZIL. Pará**: Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, 19.II.1997, col. H. Sotão & al. (MG-199684).

Additional specimen examined: **BRAZIL. Rio Grande do Norte**: Natal, Parque Estadual Dunas do Natal, 15.VII.2006, col. E.P. Fazolino & al. (UFRN-Fungos 334).

Taxonomic remarks—*Geastrum saccatum* is characterized mainly by its well-delimited, fibrillose peristome and sac-like, sessile endoperidium. It resembles *G. lageniforme* but differs in its smaller and wider rays and a mycelial layer lacking longitudinal striations (Soto & Wright 2000). Macroscopically it resembles young *G. triplex* specimens, but at maturity the pseudoparenchymatous layer of

*G. triplex* detaches from the fibrous layer. Another marked difference between these two species is the much smaller basidioma of *G. saccatum*.

This is the second record of *G. saccatum,* first recorded by Hennings (1904), from the Amazon rainforest.

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